

The Physics of ELFE.¹

Bernard Pire

Centre de Physique Théorique², Ecole Polytechnique, F91128 Palaiseau, France

Abstract

This paper presents an overview of the physics program of the 15-30 GeV continuous beam electron facility proposed by the European community of nuclear physicists to study the quark and gluon structure of hadrons. The goal of this new facility is to explore the quark structure of matter by exclusive and semi-inclusive electron scattering from nuclear targets.

1 Introduction

Recently, the Nuclear Physics European Collaboration Committee (NuPECC) of the European Science Foundation has recommended [1] the construction of a 15-30 GeV high intensity continuous beam electron accelerator. The goal of this new facility is to explore the quark structure of matter by exclusive and semi-inclusive electron scattering from nuclear targets, since although one knows the microscopic theory for the strong interactions, which is the quantum chromodynamics of colored quarks and gluons [2], *one does not understand how quarks build up hadrons*.

The ELFE research program[3] lies at the border of nuclear and particle physics. Most of the predictions of QCD are only valid at very high energies where perturbation theory can be applied. Understanding however how hadrons are built, is the domain of confinement where the coupling is strong. Up to now there are only crude theoretical models of hadronic structure inspired by QCD. One hopes that in the next ten years major developments of nonperturbative theoretical methods such as lattice gauge theory will bring a wealth of results on the transition from quark to hadron. However, many theorists think that it is fundamental to guide theory with accurate, quantitative and interpretable measurements obtained by electron scattering experiments.

The research program of ELFE addresses the questions raised by the quark structure of matter: the role of quark exchange, color transparency, flavor and spin dependence of structure functions and differences between quark distributions in the nucleon and nuclei, color neutralization in the hadronization of a quark... All these questions are some of the many exciting facets of the fundamental question:

“How do color forces build up hadrons from quarks and gluons? ”

ELFE will focus on the following research topics:

- **Hadron structure** as revealed by hard exclusive reactions : baryon form factors, real and virtual Compton scattering, electro and photo-production of mesons ($\pi, K, \rho, \phi \dots$), meson (π, K, \dots) form factors.
- **Evolution from mini-hadron to hadron** in Color Transparency experiments.
- **Vector mesons and heavy quarks**: diffractive production and exclusive scattering at high transfers.

¹presented at the 7th Journées d'Etudes SATURNE, Ramatuelle (1996)

² Centre de Physique Théorique is unité propre du CNRS.

- **Space time picture of quark hadronisation** through the study of absorption by nuclear medium.
- **Separation of Valence and Sea** content of the proton by tagged structure functions measurements.
- **Study of spin structure** of the nucleon through semi-inclusive experiments.
- **Light nuclei short distance structure** through form factor measurements and deep inelastic scattering at $x > 1$.

2 Hard Exclusive reactions: A new tool

Exclusive reactions are processes in which the final state is completely resolved. They are important since at high momentum transfers they allow to study what may be called the simplest non perturbative objects. This is due to a remarkable factorization property of scattering matrix elements into a long distance confinement controlled hadronic distribution amplitude convoluted with a short distance perturbatively calculable quark hard scattering amplitude.

One starts with the Fock expansion[4] with a fixed number of quarks and gluons for a proton state of momentum P :

$$|P\rangle = \Psi_{qqq}^P|qqq\rangle + \Psi_{qqq,g}^P|qqq,g\rangle + \Psi_{qqq,q\bar{q}}^P|qqq,q\bar{q}\rangle + \dots$$

where $\psi_l^P(x_i, \vec{k}_i^\perp)$ describes how the l quarks and gluons share the proton momentum. The wave functions Ψ_l^P are functions of light-cone momentum fraction x_i , transverse momentum k_i^\perp and helicities. They contain the information on quark confinement dynamics. Here the quarks are “current” quarks and not “constituent” ones.

Of particular interest is Ψ_{qqq}^P , the valence proton wave function. This is the simplest non-perturbative object which recalls the color singlet nature of a confined quark configuration.

Let us take the example of the proton form factor. Dimensional arguments easily show that the “three quarks” hard scattering amplitude gives a contribution proportional to $[1/Q^2]^2$ due to the two gluon propagators, whereas the “3 quarks 1 gluon” amplitude, requiring three gluon propagators, contributes for $[1/Q^2]^3$. The argument may be repeated for more participating constituents and for any reactions. Thus, the valence component Ψ_{qqq}^P turns out to be the dominant one in hard exclusive reactions.

Factorization is then the statement that a hard matrix element can be written as

$$\mathcal{M} \simeq \phi_{qqq}^{*P} \otimes T_H^{qqq,qqq} \otimes \phi_{qqq}^P, \quad (1)$$

for a reaction with one proton in the initial and in the final state, up to $1/Q^2$ corrections. Integrals over momentum fractions x_i and y_j are implicit. Here

$$\phi_{qqq}^P(x_i) = \int [dk^\perp] \Psi_{qqq}^P(x_i, \vec{k}_i^\perp)$$

is the proton Valence Distribution Amplitude, and $T_H^{qqq,qqq}$ is a hard scattering amplitude, calculable in perturbative QCD.

The applicability of this factorization in a definite energy domain can be tested through some definite statements, such as the logarithmically corrected dimensional counting rules, the helicity conservation law and the appearance of color transparency. The few data available [5] (see figure 2) indicate that the ELFE parameters indeed correspond to this well defined physics domain. Nevertheless, checking factorization will be a necessary prelude of the experimental program at ELFE.

Fig 1: The factorization of a hard scattering amplitude

Fig.2: Q^2 evolution of the proton form factor. Above 10 GeV², scaling is established.

The analysis of QCD radiative corrections to any exclusive amplitude has shown [4] that the factorized distribution amplitudes obey a renormalization group equation, leading to a well understood evolution in terms of perturbative QCD. At asymptotic Q^2 , the distribution amplitudes simplify, e.g. for the proton valence distribution amplitude:

$$\phi_{qqq}^P(x_1, x_2, x_3, Q^2) \rightarrow K x_1 x_2 x_3 \delta(1 - x_1 - x_2 - x_3) \quad (2)$$

The Q^2 evolution is however sufficiently slow for the distribution amplitude to retain much information at measurable energies on confinement physics. The experimental strategy of ELFE physics is thus to sort out the hadron distribution amplitudes from various exclusive reactions to learn about the dynamics of confinement.

At finite Q^2 the proton valence wave-function can be written as a series derived from the leading logarithmic analysis, in terms of Appell polynomials $P_i(x_i)$, as [4]

$$\begin{aligned} \phi_{qqq}^P(x_i, Q^2) = x_1 x_2 x_3 \delta(1 - x_1 - x_2 - x_3) \{ & \left(\frac{\alpha_S(Q^2)}{\alpha_S(Q_0^2)} \right)^{\lambda_0} A_0 + \frac{21}{2} \left(\frac{\alpha_S(Q^2)}{\alpha_S(Q_0^2)} \right)^{\lambda_1} A_1 P_1(x_i) \\ & + \frac{7}{2} \left(\frac{\alpha_S(Q^2)}{\alpha_S(Q_0^2)} \right)^{\lambda_2} A_2 P_2(x_i) + \dots \} \end{aligned} \quad (3)$$

with $\lambda_0 = \frac{2}{27} < \lambda_1 < \lambda_2 \dots$. The unknown coefficients A_i are governed by confinement dynamics.

Due to the smallness of exclusive amplitudes at large transfers, existing high energy electron accelerators, designed to study electroweak physics, cannot give access to these distribution amplitudes. The only way to study exclusive reactions at large transfer is to use a dedicated high intensity continuous beam accelerator.

Photo- and electro-production of mesons at large angle will enable to probe π and ρ distribution amplitudes in the same way. The production of $K\Lambda$ final states will enable to explore strange quark production, for which the diagrams in the hard process are more

restricted. Not much theoretical analysis of these possibilities has however been worked out except under the simplifying assumptions of the diquark model [6].

3 Color Transparency

Configurations of small transverse extension are selected by hard exclusive reactions. Indeed, in the Breit frame where the virtual photon is collinear to the incoming proton which flips its momentum, the first hit quark changes its direction and gets a momentum $O(Q)$; it must transmit this information to its comovers within its light cone; this can only be achieved if the transverse separation is smaller than $O(1/Q)$. This is the basis of the Color Transparency phenomenon [7].

Hard exclusive scattering (with a typical large Q^2 scale) selects a very special quark configuration: the minimal valence state where all quarks are close together, forming a small size color neutral configuration sometimes referred to as a *mini hadron*. This mini hadron is not a stationary state and evolves to build up a normal hadron.

Such a color singlet system cannot emit or absorb soft gluons which carry energy or momentum smaller than Q . This is because gluon radiation — like photon radiation in QED — is a coherent process and there is thus destructive interference between gluon emission amplitudes by quarks with “opposite” color. Even without knowing exactly how exchanges of soft gluons and other constituents create strong interactions, we know that these interactions must be turned off for small color singlet objects. Letting the mini-state evolve during its travel through different nuclei of various sizes allows an indirect but unique way to test how the squeezed mini-state goes back to its full size and complexity, *i.e.* how quarks inside the proton rearrange themselves spatially to “reconstruct” a normal size hadron. In this respect the observation of baryonic resonance production as well as detailed spin studies are mandatory.

To the extent that hard scattering reactions in free space are understood as a function of Q^2 , experiments on nuclei will allow to measure the color screening properties of QCD. The quantity to be measured is the transparency ratio T_r defined as:

$$T_r = \frac{\sigma_{\text{Nucleus}}}{Z\sigma_{\text{Nucleon}}} \quad \text{or} \quad \frac{\sigma_{\text{Nucleus}}}{A\sigma_{\text{Nucleon}}} \quad (4)$$

The gauge nature of QCD leads to the prediction that $T_r \rightarrow 1$ as Q^2 grows. At large values of Q^2 , dimensional estimates suggest that T_r scales as a function of $A^{1/3}/Q^2$ [8]. The approach to the scaling behavior as well as the value of T_r as a function of the scaling variable determine the evolution from the pointlike configuration to the complete hadron. This effect can be measured in an $(e, e'p)$ reaction that provides the best chance for a *quantitative* interpretation, and in vector meson diffractive electroproduction as recently observed at Fermilab (see below).

4 Vector Meson production

Diffractive vector meson production is usually understood in terms of Pomeron exchange. The nature of the Pomeron is however quite subtle. Recent theoretical and experimental progresses have strengthened the case for a detailed study in different energy ranges; in the very high energy domain of HERA, it has been shown[9] that the vector meson diffractive electroproduction amplitude at high Q^2 was calculable in terms of the gluon structure function and of the meson distribution amplitude. In the fixed angle regime (when ρ is produced at large transfer and the energy is not much higher), the hard exclusive reaction framework should apply. The case of heavy quarkonia (Φ and J/Ψ) is particularly interesting but demands quite high luminosities. In the medium energy range,

Fig.3: The Transparency ratio as measured at FNAL[10]
in diffractive electroproduction of ρ

ELFE will allow a detailed analysis of diffractive as well as high p_T electroproduction at various Q^2 and with controlled inelasticity.

Using nuclear targets will enable to scrutinize the formation and propagation of the final state. The phenomenon of color transparency should also be at work here. The data (Fig.3) on diffractive electroproduction of ρ at high energy [10] indeed show an interesting increase of the transparency ratio for $Q^2 \simeq 7\text{GeV}^2$. Since the initial lepton energy is around $E \simeq 200\text{GeV}$ the boost is high, which yields a short travel time for the produced mini-hadron inside the nucleus; one should however note that it is very difficult to disentangle diffractive from inelastic events in this experiment, which is of crucial importance to correctly define the transparency ratio. Moreover gluon exchange may open the possibility to induce color rearrangements between quark clusters in nuclei in order to study "hidden color" components such as a color octet-color octet component in the deuteron.

The study of polarized Λ and open charm electroproduction will bridge the gap between the physics of the heavy quark sector and the physics of hadronization.

5 Semi-inclusive reactions and hadronization

Most of the time, the quark scattered by a large Q^2 virtual photon leads to a complex multiparticle final state through the process of hadronization. These events are better analyzed through an inclusive or semi-inclusive formalism. The fully inclusive case has already been much studied. Up to order $1/Q$ and including polarization, the cross section may be written as [11]

$$\begin{aligned} \frac{d\sigma}{dx dy} = & \frac{4\pi\alpha^2 s}{Q^4} \left\{ \left(\frac{y^2}{2} + 1 - y \right) x f_1(x) + \lambda_e \lambda y \left(1 - \frac{y}{2} \right) x g_1(x) \right. \\ & \left. - \lambda_e |\mathbf{S}_\perp| \frac{M}{Q} 2y \sqrt{1-y} \cos(\phi_s) x^2 g_T(x) \right\}. \end{aligned} \quad (5)$$

with the usual scaling variables $x = Q^2/2P \cdot q$ and $y = P \cdot k/P \cdot q$, and the sum over quark flavors is understood. The twist-3 function surviving after k_T -integration, $g_T(x)$, appears at subleading order.

ELFE will mostly contribute to inclusive studies in two specific directions:

- the $x > 1$ region where exotic phenomena - such as the existence of six-quark structures in the nucleus - reveal themselves.
- the higher twist components may be separated by careful use of polarization asymmetries; this will help to understand quark-gluon correlations in the nucleon and nuclei.

Semi-inclusive scattering studies have not been much developped up to present work with the Hermes detector at HERA. For these observables, one defines the scaled hadron energy $z = \frac{E_{p'}}{\nu}$, where ν is the virtual photon energy and $E_{p'}$ the produced hadron energy, and the invariant mass squared W^2 of the hadronic final state $W^2 = m^2 + Q^2 + 2m\nu$ (m is the mass of the initial hadron). Including a dependence on the transverse momentum [11] through a function \mathcal{G} in the quark distribution and fragmentation functions, one gets

$$\begin{aligned}
\frac{d\sigma}{dx dy dz d^2\mathbf{P}_{h\perp}} &= \frac{4\pi\alpha^2 s}{Q^4} \sum_{a,\bar{a}} e_a^2 \left(\frac{y^2}{2} + 1 - y \right) x f_1^a(x) D_1^a(z) \frac{\mathcal{G}(Q_T; R)}{z^2} \\
&- \frac{4\pi\alpha^2 s}{Q^4} \lambda \sum_{a,\bar{a}} e_a^2 (1 - y) \sin(2\phi_h) \frac{Q_T^2 R^4}{M M_h R_H^2 R_h^2} x h_{1L}^{\perp a}(x) H_1^{\perp a}(z) \frac{\mathcal{G}(Q_T; R)}{z^2} \\
&- \frac{4\pi\alpha^2 s}{Q^4} |\mathbf{S}_{\perp}| \sum_{a,\bar{a}} e_a^2 \left\{ (1 - y) \sin(\phi_h + \phi_s) \frac{Q_T R^2}{M_h R_h^2} x h_1^a(x) H_1^{\perp a}(z) \right. \\
&\quad \left. + (1 - y) \sin(3\phi_h - \phi_s) \frac{Q_T^3 R^6}{2M^2 M_h R_H^4 R_h^2} x h_{1T}^{\perp a}(x) H_1^{\perp a}(z) \right\} \frac{\mathcal{G}(Q_T; R)}{z^2} \\
&+ \frac{4\pi\alpha^2 s}{Q^4} \lambda_e \lambda \sum_{a,\bar{a}} e_a^2 y \left(1 - \frac{y}{2} \right) x g_{1L}^a(x) D_1^a(z) \frac{\mathcal{G}(Q_T; R)}{z^2} \\
&+ \frac{4\pi\alpha^2 s}{Q^4} |\mathbf{S}_{\perp}| \sum_{a,\bar{a}} e_a^2 y \left(1 - \frac{y}{2} \right) \cos(\phi_h - \phi_s) \frac{Q_T R^2}{M R_H^2} g_{1T}^a(x) D_1^a(z) \frac{\mathcal{G}(Q_T; R)}{z^2}.
\end{aligned} \tag{6}$$

All six twist-two x - and \mathbf{p}_T -dependent quark distribution functions for a spin 1/2 hadron can thus be accessed in leading order asymmetries with polarized lepton and hadron. One of the asymmetries involves the transverse spin distribution h_1^a [12]. On the production side, only two different fragmentation functions are involved, the familiar unpolarized fragmentation function D_1^a and the "transverse spin" fragmentation function $H_1^{\perp a}$.

The semi-inclusive physics program of ELFE is twofold:

- a better understanding of the proton content will be achieved with the help of tagged structure function measurements: the expected high luminosity and particle identification will allow a precise measurement of the strangeness or intrinsic charm content at medium to high x . Polarization measurements will open the study of transverse spin [13] as well as helicity distributions, hopefully separating valence and sea quark components. For instance, $\Delta_{\perp} q(x)$ may be measured in the semi-inclusive process

$$e^- N^{\uparrow} \rightarrow e^- \Lambda^{\uparrow} + X; \tag{7}$$

since the polarization of the Λ is proportional to $\Delta_{\perp} q(x) \times \Delta_{\perp} D_{\Lambda^{\uparrow}/q}(z)$. The second factor is the analysing power of the "quark polarimeter" $q^{\uparrow} \rightarrow \Lambda^{\uparrow} + X$.

- the use of nuclear targets will lead to the precise measurement of attenuation ratio

$$R_A(z, \nu) = \left(\frac{1}{\sigma_A} \frac{d\sigma_A}{dz} \right) / \left(\frac{1}{\sigma_D} \frac{d\sigma_D}{dz} \right)$$

of hadron yields on a nucleus A and on deuteron D. Relating this piece of information to the physics of the color neutralization process requires some modelling. One first needs

to take into account the loss of energy of the scattered quark in the nuclear medium, presumably by gluon radiation in a hopefully calculable way. After some characteristic time, a colorless wave packet is formed which further interacts strongly within the nucleus, leading finally to the detected hadron. The flavor, ν and z dependence of R_A will help discriminating models based on different assumptions and scenarios.

6 Accelerator and detectors

The choice of the energy range of 15 to 30 GeV for the ELFE accelerator is fixed by a compromise between

- Hard electron-quark scattering: one must have sufficiently high energy and momentum transfer to describe the reaction in terms of electron-quark scattering. The high energy corresponds to a very fast process where the struck quark is quasi-free. High momentum transfers are necessary to probe short distances.
- The smallness of the exclusive cross sections when the energy increases, as exemplified by the quark counting rules [4].
- The size of the nucleus as a femto-detector is of the right order of magnitude provided the Lorentz boost is not so large that most of the physics happen outside. This prohibits very large energies, as exemplified by the data obtained at $O(200\text{GeV})$ at the Cern muon beam, which show negligible nuclear effects.

Exclusive and semi-inclusive experiments are at the heart of the ELFE project. To avoid a prohibitively large number of accidental coincident events a high duty cycle is imperative. The ELFE experimental program also requires a high luminosity because of the relatively low probability of exclusive processes. Finally a good energy resolution is necessary to identify specific reaction channels. A typical experiment at 15 GeV (quasielastic scattering for instance) needs a beam energy resolution of about 5 MeV. At 30 GeV the proposed experiments require only to separate pion emission.

Due to the very low duty cycle available at SLAC and HERA (HERMES program) one can only perform with these accelerators inclusive experiments and a very limited set of exclusive experiments.

*ELFE will be the first high energy electron beam beyond 10 GeV
with both high intensity and high duty factor.*

The design proposed in 1992 for the machine[3] consisted of a 1 km superconducting 5 GeV linac, with three recirculations. A different design is now considered which combines a test linac of 30 GeV with 1 % duty cycle for the future e^+e^- collider (TESLA) and the existing HERA ring for stretching the pulse [14]. The various components of the ELFE experimental physics program put different requirements on the detection systems that can be satisfied only by a set of complementary experimental equipment. The most relevant detector features are the acceptable luminosity, the particle multiplicity, the angular acceptance and the momentum resolution. High momentum resolution (5×10^{-4}) and high luminosity (10^{38} nucleons/cm²/s) can be achieved by magnetic focusing spectrometers. For semi-exclusive or exclusive experiments with more than two particles in the final state, the largest possible angular acceptance ($\sim 4\pi$) is highly desirable. The quality and reliability of large acceptance detectors have improved substantially in the last two decades. The design of the ELFE large acceptance detectors uses state of the art developments to achieve good resolution and the highest possible luminosity.

7 CONCLUSIONS

The ELFE research program lies at the border of nuclear and particle physics. Most of the predictions of QCD are only valid at very high energies where perturbation theory can be applied. In order to understand how hadrons are built, however, one has to go in the domain of confinement where the coupling is strong. It is fundamental to guide theory by the accurate, quantitative and interpretable measurements obtained by electron scattering experiments, in particular in exclusive reactions.

This research domain is essentially a virgin territory. There are only scarce experimental data with poor statistics. This lack of data explains to a large extent the slow pace of theoretical progress. The situation can considerably improve due to technical breakthroughs in electron accelerating techniques. We believe that future significant progress in the understanding of the evolution from quarks to hadrons will be triggered by new information coming from dedicated machines such as the ELFE project.

The goal of the ELFE research program, starting from the QCD framework, is to explore the coherent and quark confining QCD mechanisms underlying the strong force. It is not to test QCD in its perturbative regime, but rather to use the existing knowledge of perturbative QCD to determine the reaction mechanism and access the hadron structure.

ELFE will use the tools that have been forged by twenty years of research in QCD, to elucidate the central problem of color interaction: color confinement and the quark and gluon structure of matter.

Acknowledgements

I would like to acknowledge the many lively discussions on Elfe with many colleagues and especially Jacques Arvieux, Christian Cavata, Bernard Frois, Thierry Gousset, Pierre Guichon, Jean-Marc Laget, Thierry Pussieux and John P. Ralston.

References

- [1] Nuclear Physics News International, Vol. 5, No. 1, 30 (1995).
- [2] *QCD 20 years later*, edited by P.M. Zerwas and H.A. Kastrup, (World Scientific, Singapore, 1993)
- [3] *The ELFE project*, edited by J. Arvieux and E. De Sanctis (Italian Physical Society, Bologna, 1993); J. Arvieux and B. Pire, Progress in Nuclear and Particle Physics **30**, 299 (1995); see also the contributions to the *Proceedings of the 1st ELFE Summer School, Cambridge (1995)*, edited by S.D. Bass and P. Guichon (Ed. Frontières, Gif, 1996).
- [4] S.J. Brodsky and G. R. Farrar, Phys Rev Lett **31** (1973) 1153; V. A. Matveev, R. M. Muradyan and A. V. Tavkhelidze, Lett. Nuovo Cimento **7**, (1973) 719; G. P. Lepage and S. J. Brodsky, Phys. Rev. D **22**, (1980) 2157; A. V. Efremov and A. V. Radyushkin, Phys. Lett. **94B**, (1980) 245; for a review, see S. J. Brodsky and G. P. Lepage in *Perturbative QCD*, edited by A. H. Mueller (World Scientific, Singapore, 1989); T. Gousset and B. Pire, *Proceedings of the 1st ELFE Summer School, Cambridge (1995)*, edited by S.D. Bass and P. Guichon (Ed. Frontières, Gif, 1995)
- [5] R.G. Arnold et al., Phys. Rev. Lett. **57** (1986) 174; for a review see P. Stoler, Phys Rep. 226 (1993) 103.

- [6] P. Kroll, M. Schurmann and W. Schweiger, *Proceedings of Quark Cluster Dynamics*, (Bad Honnef, Germany 1992), edited by K. Goeke (Springer-Verlag, 1992) p 179; M. Anselmino *et al.*, Rev. Mod. Phys. **66** (1993) 195.
- [7] for a long list of references, see P. Jain, B. Pire and J.P. Ralston, to be published in Physics Reports (1996); see also L. Frankfurt, G.A. Miller and M. Strikman, Comments Nucl. Part. Phys. **21**, (1992) 1.
- [8] B. Pire and J.P. Ralston, Phys. Lett. **B256** (1991) 523.
- [9] M.G. Ryskin, Z. Phys. **C37**, (1993) 89 ; S.J. Brodsky *et al*, Phys. Rev. **D50**, (1994) 3134; L. Frankfurt, W. Zoepf and M. Strikman, Tel Aviv preprint TAUP 2290-95 (1995).
- [10] M.R. Adams *et al*, Phys. Rev. Lett. **74**, (1995) 1525.
- [11] R.D. Tangerman and P.J. Mulders, Phys. Rev. D **51** (1995) 3357; Phys. Lett. B **352** (1995) 129; P.J. Mulders and R.D. Tangerman, NIKHEF report 95-053; P.J. Mulders, Proc. on the Prospects of Spin Physics at HERA, Zeuthen (1995), DESY report 95-200.
- [12] J.C. Collins, Nucl. Phys. **B396** (1993) 161.
- [13] X. Artru and M. Mekhfi, Z. Phys **C45** (1990) 669; J.L. Cortes, B. Pire and J.P. Ralston, Z. Phys **C55** (1992) 409; R.L. Jaffe and X. Ji, Nucl. Phys **B375** (1992) 527; F. Baldrachini, N.S. Craigie, V. Roberto, M. Socolovsky, Fort. der Physik **29** (1981) 505; X. Artru, M. Mekhfi, Nucl. Phys. **A532** (1991) 351c.
- [14] B. Bonin, these proceedings.

This figure "fig1-1.png" is available in "png" format from:

<http://arXiv.org/ps/hep-ph/9602290v1>